McGILL UNIVERSITY PUBLICATIONS

SERIES XIV (PHYSIOLOGY) No. 20

Experiments and Observations on Crustacea, Part VII: Some Structural and Physiological Features of the Valviferous Isopod Chiridotea.

by

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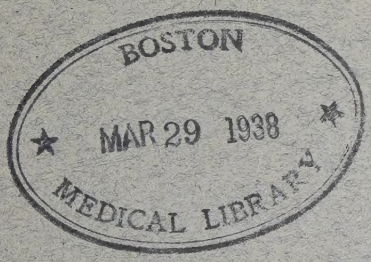

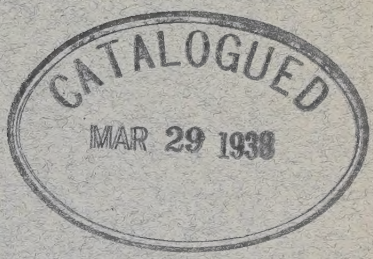

Reprinted from Proceedings of the Royal Society of Edinburgh,
Vol. 46, 1927, pp. 334-348.

MONTREAL, 1927

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XXX.—Experiments and Observations on Crustacea. Part VII: Some Structural and Physiological Features of the Valviferous Isopod Chiridotea.

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(MS. received May 24, 1926. Read July 5, 1926.)

The Idoteidæ constitute the most important family of valviferous Isopods They are divided into two sub-families, one of which, the Glyptonoteinæ, contains four genera, *Glyptonotus*, *Macrochiridotea*, *Mesidotea*, and *Chiridotea*, each represented by at least two species. *Glyptonotus*, a giant among Isopods, is found in the Antarctic; *Macrochiridotea*, of much less size, is subantarctic (Patagonia and Tierra del Fuego). *Mesidotea*, which may also attain large dimensions, is found in and around the Arctic; *Chiridotea*, of small size, occurs along the eastern shores of North America. A fossil genus, *Proidotea*, showing affinities rather with the northern than with the southern group, has been described from Oligocene deposits in Rumania.

All members of the sub-family show a sharp separation of the thoracic appendages into three anterior "gnathopods" or grasping limbs, and four posterior "peræopods" or ambulatory limbs. In the other subdivision of the family, the Idoteinæ, the thoracic limbs are all peræopods, none of them being obviously specialised as grasping organs.

The true Antarctic representatives of the Glyptonoteinæ differ from the northern forms in two outstanding structural characters. Suppose we reckon the thoracic tergites as seven in number; in *Glyptonotus* the first of these segments has fused with the head, while the coxopodites of the first four thoracic appendages have become welded to their corresponding tergites, leaving the last three still separated. In the northern genera the head is joined to the first thoracic tergite by a movable articulation, while the coxopodites of the first thoracic appendages alone have completely fused with their tergites. The welding together of important segments has been carried further in *Glyptonotus* than in these others. From the published description and drawings of *Macrochiridotea* by Ohlin (1907) it is impossible to say more than that this form rivals, while it may surpass, *Glyptonotus* in respect of the fusion of segments.

The present communication forms a sequel to a previous paper (Tait

(1917 *a*)) based on examination of spirit specimens of *Glyptonotus*. At the Atlantic Biological Station, St Andrews, New Brunswick, an opportunity occurred of studying the genus *Chiridotea* in the living condition. As the available accounts of the whole sub-family deal almost exclusively with systematic features, it seemed desirable to place on record some facts relating to the natural history of *Chiridotea*.

Owing to their diminutive size, the American representatives of the Glyptonoteinæ are not in all respects the most suitable for study, and observation is complicated by the necessity of using almost at every stage the dissecting lens or the microscope. Here, however, the preliminary study of the dead *Glyptonotus* was of marked assistance.

The two Species of Chiridotea.—Of the two species of *Glyptonotus*, one (*acutus*) has a different distribution and descends to greater depths than the other (*antarcticus*). The same is true of the two species of *Chiridotea*. Though they inhabit identical waters, *C. cæca* has adapted itself to beach-life, and may be collected on the shore at half or three-quarter ebb. *C. tuftsii* has to be taken with the dredge; from the line of low water it descends to a depth of 25 fathoms. Both species live on sandy ground. The smaller species, *tuftsii* (maximum length 6 mm.), inhabits only fine, uniform sand, the particles of which are from 0·2 mm. to 0·3 mm. in diameter. The more sturdy *C. cæca* (maximum length 13 mm.) occurs on sand that is mixed with occasional fragments of shell and stone, the diameter of the sand particles varying from 0·5 mm. to 1·5 mm.

According to Harger (1880), *C. tuftsii* is distinguished from *C. cæca* "by its smaller size and larger antennæ, which are about twice as long as the antennulæ and bear a slender flagellum. The eyes are also more conspicuous than in *C. cæca*." In her analytical key to the species, Richardson (1905) instances three points of difference: (1) the length of the antennæ, those of *cæca* extending only to the anterior margin of the first thoracic segment; (2) the shape of the front of the head, that of *cæca* being almost straight, that of *tuftsii* being deeply excavate between the antero-lateral angles; (3) the greater relative length of the antennules of *cæca*. Another point of specific difference discovered in the course of the present investigation is that the dactylopodite of the first gnathopod of *tuftsii* bears at its extremity a double claw, whereas that of *cæca* is simple, as it also is in the remaining gnathopods of both forms.

As *C. cæca* could be procured in the immediate vicinity of the laboratory, it was chiefly used for the observations which follow. A small supply of *tuftsii* was also obtained and kept alive for comparison of behaviour, but the number of available specimens was too few for regular use.

General Observations.—Along with the valved and rigid water-propelling mechanism of the pleon, the uncommon division of the thoracic limbs of the Glyptonoteinæ suggests some distinctive type of locomotion. *Chiridotea* proves indeed to have an exceptional range of locomotor activities. It swims with ease, if not with speed; it is of course reptant; but its outstanding characteristic is its capacity for burrowing. Sunk a few millimetres below the sand, it can tunnel its way continuously for many inches, or even feet, at a time, heaving the surface above it into an elevation and leaving a furrow behind, which at a superficial glance resembles the track of a periwinkle. *Cœca* can tunnel both when the sand is covered by water and after the tide has receded. As Verrill (1873) reported: "On the moist sand-flats crooked tracks made by the *Idotea cœca* may generally be seen. This little Isopod burrows like a mole just beneath the surface of the sand, raising it up into a little ridge as it goes along, and making a little mound at the end of the burrow, where the creature can usually be found." Among aquatic animals a combination of creeping and swimming is common; so is the association of reptant and of mining habits. The union of all three in the same individual is exceptional, and gives to the possessor a peculiar place among its crustacean relatives.

In a flat dish strewn to the depth of an inch with sand and holding another inch of water, which is renewed from time to time, both species thrive well in the laboratory. Of robust build in spite of its somewhat transparent appearance, *C. cœca* takes little or no harm from the frequent handling incidental to close observation. In other respects, too, it is an accommodating animal. On the sea-beach as well as in its sand-tray it is not disturbed by the presence or movements of an observer. In search of food it is indefatigably active, and roams about for hours on end exploring the sand-surface. Occasionally it takes little upward flights off the bottom, when as often as not it turns turtle and swims back downwards, thus giving an excellent view of its ventral surface and pleonic propulsor mechanism. *C. tuftsii*, which lives at a greater depth, has not developed this habit of skimming the surface of the water.

In a natural tunneller like *Chiridotea* one would scarcely look for speed, and all the movements of the animal are deliberate rather than rapid or sudden. Hodgson (1910), who accompanied the *Discovery* expedition to the Antarctic, reports that *Glyptonotus* also is "of sluggish habits." A grown specimen of *C. cœca* while walking covers a distance of some 5 cm. per second, while its rate of progression in swimming is about twice as fast; thus the creature is extremely easy of capture, and when fished up between

the fingers makes no jerky attempts at escape. The chief difficulty in watching it under the microscope is due to its untiring activity. Resting rarely, and then only for a few seconds at a time, it trudges round and round, and so eludes consecutive observation. Presented with a small morsel of meat, however, it clutches the fragment to its mouth and becomes suddenly still; until its voracious appetite is satisfied it will now lie in any position, prone, supine, or on its side, offering every opportunity for the most detailed examination.

Food.—In the alimentary canal of *Glyptonotus* I could find only animal food. Harger (1880) seems to infer that *Chiridotea* may consume green algæ, yet *Zostera* and algæ of various kinds offered to hungry individuals are consistently ignored, whereas any kind of animal food—whether of sea or of land origin—is greedily consumed. A crushed insect or a caterpillar left to float on the surface of the water is shortly surrounded by an inverted cluster of the hungry Isopods, which with hands and mouths to the prey, and with pleopods gently beating, drive the floating carcase round and round till nothing but the chitinous casing remains. Similarly a fragment of fish or of mollusc forms a most attractive bait. From the fact that Hansen (1886) found portions of Chætopods and mud in the digestive tube of *M. entomon*, Racovitza and Sevastos (1910) suppose these forms to be omnivorous. Since Chætopods swallow mud, it is plain that the premises do not warrant this deduction.

Like every crustacean that is not parasitic, *Chiridotea* can deal only with food that has a certain consistency, its equipment not being adequate for the ingestion of simple fluid nutriment: all its food must be capable of being grasped by the gnathopods. At the same time, there are limits to its masticatory powers. While the more powerful *Glyptonotus* is able to crush Amphipods and to tear the limbs of Ophiuroids, *Chiridotea* prefers to pick soft parts. No matter how hard it tries, it fails to sever vertebrate connective tissue, through which the mandibles even of *Glyptonotus* are unable to make a clean shear; when the muscle fibres are cleaned off a piece of fish muscle, the fibrous material is invariably discarded. So too the chitinous tendon of crab muscle is eschewed, the plate being gnawed bare of muscle fibres. When pressed by hunger, *Chiridotea*, like *Ligia*, will, however, make entry through the cuticle of a recently moulted relative in order to reach the softer tissue within (*cf.* Tait (1925)).

Chiridotea is not a pugnacious animal like a crab, and it is interesting to note how a young and a grown animal may, in perfect amity, feed mouth to mouth at the same small piece of meat. The two may roll over and over in their efforts to keep hold of the moving morsel, but nothing in

the nature of a fight occurs; there is no attempt at intimidation on the part of the older animal, and no sign of fear on the part of the younger When a crowd of animals surrounds a single small block of food a newcomer makes his way in as best he can, the others showing no resentment at the disturbance he causes. The indications seem to be that in its natural haunts *Chiridotea* depends for its livelihood mainly upon the chance discovery of animals already dead. The creature is not adapted for offensive tactics, for overwhelming and slaughtering living prey, its slenderly constructed gnathopods being mere organs of prehension and not weapons of attack.

The feeding Process.—The gnathopods are not even employed like the chelæ of a crab to tear food to pieces. Their part is to seize it, to manipulate it, and steadily to feed it to the mandibular mill. Of these operations the most complicated is the second, and the feverish haste with which a piece of food, by the co-ordinated action of these six limbs, can be spun around and successively whisked into new positions until a suitable portion finally presents itself to the maxillæ and mandibles, requires to be witnessed in order to be appreciated. The behaviour of the animal on these occasions is as if its life depended on rapidity of action. The gnathopods are abundantly provided with tango-receptors; the gustatory receptors are solely on the mouth parts. A piece of fish skin, for instance, may be approximated over and over again to the mouth, but it is pulled back for new adjustment each time the distasteful external surface touches the chemo-receptors. Only when the connective tissue surface happens to be turned towards the mandibles does the process of manducation begin. The antennæ play no part in the feeding process.

Examination of the gnathopods and mouth parts of the dead *Glyptonotus* suggested the following statement: "In manducation the gnathopodal hands (each one of which can be brought to lie under the mouth), the first maxillæ and the mandibles would appear to be chiefly concerned. The gnathopods probably act as packers, holding the food towards the mandibles and pushing it forward between each bite. . . . Repeated mandibular adductions alone are insufficient to cause any forward movement, as one can readily prove by trial on the dead animal with a wad of softened paper to represent food." Observation of the living *Chiridotea* showed that these deductions had been correctly drawn. We can perhaps better appreciate the rôle of the gnathopods if we compare the mandibles with the teeth of mammals. In mammals any pabulum has to be continuously fed to the teeth by an accessory motor mechanism, *e.g.* the lips or the tongue. In Isopods, which have no tongue to draw food

inwards, the gnathopods act as this accessory mechanism. In this connection, too, it is perhaps worthy of mention that the mandibles of all the Glyptonoteinæ are devoid of a movable palp, a characteristic that tends throughout the Isopoda to be associated with the presence of anterior prehensile appendages.

Whereas all three pairs are used in manipulation, the anterior pair, as is the rule among the Idoteidæ generally, is particularly concerned in the packing process. These appendages are frequently assisted by one or both members of the second pair, but if the fragment of food is not large, and particularly if it consists of a solitary filament, it is fed to the mandibles only by the first pair, the other gnathopods, like the peræopods, meantime remaining motionless. Within the merocarpus of these two appendages the filament is held to the mouth, and by rhythmic action, at a regular rate of about once a second, pushed smartly towards the orifice and more slowly withdrawn again. As the morsel becomes reduced in size tag ends and ragged pieces are hastily and deftly gathered in by four or more hands, the first two (or first four) being reserved throughout for immediate application to the mouth.

Dissection of the ventral skeleton of the cephalosome of *Glyptonotus* revealed the presence of a movable maxillo-sternal framework capable of a considerable range of dorsi-ventral displacement. This structure, no doubt a general feature of isopodan anatomy, carries the paragnaths, the maxillæ, and the maxillipeds. It proved a hard matter in *Chiridotea* to observe the up-and-down movement of this framework during feeding, for it remains hidden by the food. Nor was it possible to determine the rate of action of the mandibles during the time of gnathopodal packing. When, however, a meal is almost finished these come into view, clipping at a considerably more rapid rate than the rhythmic push of the gnathopods, say four to five times a second. Their rapid action at this particular stage was all the more striking because so unexpected.

The alimentary Canal.—We may recall certain features of the alimentary canal of *Glyptonotus*. It is divided into three distinct parts: an elegantly designed foregut, confined to the cephalon; a midgut, capable of considerable distension, reaching from the commencement of the primitive thorax of eight segments as far as the sternite of the fifth or sixth (conventional) thoracic somite; here a sphincter intervenes between it and the hindgut, which runs from the sixth somite through the posterior thorax and pleon to the anus. The foregut, sometimes inappropriately called the "gizzard," was proved not to triturate the food, but to function as part of the propelling mechanism connected with swallowing. By

means of overlapping chitinous processes it also prevents forward regurgitation of food material that has already reached the midgut. The latter was found to contain blocks of food, of a length equal to the bite of the mandibles, sometimes in strings like a line of sausages, the separate blocks being joined by incompletely divided connective tissue. The hepatic cæca, which open into the upper part of the midgut, were in the alcohol-preserved specimens badly macerated; neither their number nor their length could be determined.

In *Chiridotea* the arrangement of the alimentary canal is very similar, except that the midgut extends about one segment farther back. There are two pairs of hepatic cæca.

By dorsal examination of a feeding specimen under appropriate illumination the movement of the foregut can be observed in part. A conspicuous arrow-shaped area of the cephalon is deeply pigmented, the base of the arrow spreading across the front of the head, its point being directed backwards. Behind the base and on either side of the point of the arrow there are two slightly elevated regions of the cephalon, of ample area and circular in outline. These two bosses represent the site of origin of the powerful adductor muscles of the mandibles (*cf.* the paper on *Glyptonotus*, p. 292). At the posterior border behind these bosses and behind the point of the pigmented arrow of the cephalosome is left a broad space almost devoid of pigment and relatively transparent. Through this space the action of the posterior valvular part of the foregut can be obscurely seen. Its backward and forward movement corresponds in time with the movements of the mandibles and gnathopods. The internal capacity of the foregut being small, there can be no doubt that with each act of swallowing a portion of food passes the valves.

The spindle-shaped midgut of *Chiridotea*, like that of *Glyptonotus*, is brown in colour, and therefore visible as a dark shadow through the relatively unpigmented ventral surface of individual animals, preferably males. In the empty condition its diameter is about one-seventh of the particular part of the thorax at which measurement is made. Parallel to it on either side is seen the shadow of two thin strands of tissue, the hepatic cæca. Each strand tapers to a point at its termination near the lower extremity of the midgut. Between the more medial cæcum and the gut intervenes a thin band of transmitted light (the animal lies supine and is illuminated from below); a similar strip of light separates the medial and the lateral cæcal shadow. Provided the animal is fasting, the outline of the fine dark shadows remains fixed in position and no movement of the organs is perceptible.

So soon as the animal commences to feed, the midgut enters into rhythmic contraction, at first of an antiperistaltic kind. A narrow band of constriction causing a deep indentation on either side commences posteriorly and runs forward at an even rate. Two or three seconds later a new constriction takes origin at the same place and courses after its predecessor. The rate of forward movement is such that two waves usually involve the midgut at the same time, but they die out before reaching the actual front end, the more motile part in this case being the posterior portion. These antiperistaltic contractions are associated with the commencement of a meal, and no doubt owe their origin either to the tasting or to the preliminary mastication of food. If the *Chiridotea*, instead of being supplied with soft muscle, is given a piece of fish skin, the connective tissue part of which is difficult to snip into pieces and to swallow, the constrictions are excited in the same way and go on for a much longer time although no food enters the midgut itself.

When food begins to enter the upper part of the midgut its presence there excites peristaltic movements which travel in the backward direction. These commence in the forward part of the midgut and carry the food as far as the sphincter at the join of the sixth and seventh thoracic somites. Thus the gut begins to dilate uniformly and equally throughout its length. As it increases, the strip of light between it and the medial pair of hepatic cæca soon disappears, and these cæca henceforward become invisible, probably by dorsal shift. The lateral pair remain throughout fully visible, though not separated from the midgut by a band of light.

Just as conspicuous and interesting as the movements of the foregut and midgut are the changes that occur in the lateral pair of hepatic cæca. As the midgut fills, each cæcum, darkening greatly in colour, is slowly pushed towards the side of the thorax, and soon exhibits a series of five large, laterally projecting pouches, one for each somite from the second to the sixth inclusive, those in the third and fourth somites being invariably the largest. Each pocket being separated from its neighbour by a deep indentation, the outer border of the cæcum becomes markedly sinuous or scalloped in outline. Each pocket of the series is seen to contract and relax again, as if in alternate systole and diastole, successive pockets along the line being in different phases of contraction at one and the same moment. The appearance inevitably suggests that a great accession of contained fluid or semi-fluid material is being transferred from one pocket to the other, and thereby churned and mixed. These cæcal movements continue in active operation long after the process of feeding and visible peristaltic movements of the gut have ceased.

The Thoracic Sternites.—In the paper on *Glyptonotus* (p. 264) it was suggested that the curious division in the middle of certain of the thoracic somites of the Glyptonoteinæ is a device for allowing of distension of the body after a meal. This surmise proves correct, and one may see that the ventral aspect of *Chiridotea*, after the animal has fed to satiety, is markedly protuberant, the halves of the divided sternites being widely separated. During fasting the split sternites come together again and even overlap slightly. It is noteworthy, too, that in *Chiridotea*, which has a relatively longer midgut than *Glyptonotus*, the last sternite of the series is also mesially divided, whereas in the latter this sternite is rigidly calcified.

After a full meal *Chiridotea* promptly buries itself under the sand and remains in hiding while digestion proceeds. At the end of twenty-four hours it is usually hungry again, and the same animal will feed to satiety each day or each second day for a long period on end.

Sense of Smell.—A number of experiments were carried out in order to determine whether *Chiridotea* is guided towards its food by any organs of special sense. These experiments showed that, whereas vision plays no perceptible part in guidance, sense of smell comes distinctly into operation, at least within a distance of an inch or two. A hungry animal, roving hither and thither, comes within olfactory range of a food morsel. Immediately its course is changed and it heads straight towards the piece of meat. Growing excited, it travels with increasing speed, until with a final rush it clutches the bait. Blinded animals behave in a quite similar fashion. When, too, the creatures are all in hiding and the sand-surface appears deserted, a piece of meat dropped into the water induces one animal after another to emerge, until in a short time many have collected about the meat. The olfactory receptors are presumably situated on the antennules (*cf.* Bethe (1897)). No ablation experiments to determine their location were, however, performed.

The Uropods of the Valvifera.—In the communication on *Glyptonotus* I dealt with the direction of rotation by which the uropods of the Valvifera have acquired their present orientation, and showed that the commonly (but not universally) accepted view of the matter is correct, viz. that the anterior border of the valviferous uropod corresponds to the mesial border of the uropod of other forms. The deduction was based on two new lines of evidence, the more important of which was the discovery that the articular foramina of the pleonic somites, roughly elliptical in shape, gradually change their direction in the same uniform sense from before backwards, until the major axis of the foramen for the uropod is antero-posterior; meantime a special articular spur situated towards the mesial

aspect of each pleopodal foramen similarly changes its direction, until in the uropodal foramen it is anterior. In other words, the change in orientation of the uropods is not so unanticipated or so abrupt as might appear, being already foreshadowed in the direction of articulation of the hinder pleopods.

One would scarcely refer to the matter again were it not that W. E. Collinge (1918), after a perfunctory examination of *Glyptonotus* accompanied by a no less perfunctory discussion of this particular question, denies the evidence. It is a little hard to know how to reply to an author who finds "no trace whatever of any such spur" on the border of the articular foramen for the uropods; who asserts by way of evidence that "the uropoda of the Valvifera . . . serve as accessory natatory organs, as in most marine isopoda"; and who, pointing out that in very young forms the right and left uropods do not meet in the middle line, then says: "This fact, we think, affords striking evidence in favour of the rotation view." He seems unaware that the view he disputes is itself a rotation view, the only matter at issue being the direction or angular sign of the rotation. He overlooks the fact that his own evidence, so far as it has any bearing on the subject, is wholly consonant with the view he claims to refute.

Apart from the fresh testimony given in the *Glyptonotus* paper as proof of the commonly held view, there remains the evidence on which this view was itself first based. This is so simple and natural that it has never received formal expression; consequently it may be as well to state it. In flexion the pleopods are horizontal and lie along the under surface of the pleon; in extension they stand at right angles to the under surface of the pleon. In flexion the uropods are likewise horizontal and lie on the under surface of the pleon; in extension they stand vertical. The only direction of rotation in virtue of which a uropod (with an originally transverse hinge) can (with an antero-posterior hinge) be brought to lie under the pleon in flexion, is one in which the mesial border so turns as to become anterior.

Sand-tunnelling.—As was surmised in the case of *Glyptonotus*, *Chiridotea* walks with its head depressed and its pleon pointing slightly upwards. It was a surprise, however, to find that in walking the gnathopods are regularly used as reptant limbs. When *Chiridotea* starts to tunnel it dips its head still more, and, clawing the sand particles with its gnathopods, throws its pleonic propulsor mechanism into vigorous action. In this way a narrow current of water is set up, whereby the animal itself is driven forwards, while the sand particles dislodged by the mesially directed gnathopods are swept backwards and deposited

behind it. The short thorax, the narrow pleon, and the mesial orientation of the gnathopods are thus seen to be correlated features which contribute to this associated action of the gnathopods and pleopods.

The stout peræopods of the animal, projecting laterally into a different body of sand, are meantime used to direct and powerfully to assist its onward course. These peræopods have both an unusual configuration and an unusual orientation, which again seem to be correlated with the tunnelling habit. Directed laterally at first, each soon bends backwards and lies parallel to the body axis. Their anterior border is thus convex. As the various spines on their constituent segments are also directed backwards, the limbs meet with minimal resistance in forward movement through the sand and maximal resistance in backward movement.

It will thus be seen that all three groups of locomotor appendages—gnathopods, peræopods, and pleopods—are used in tunnelling, and that their shape and structural disposition are to a large extent conditioned by this habit. This in turn suggests a wider inference. In dealing with the thoracic appendages of the Peracarida, the author (1917 *b*) introduced the term "limb-taxis" to designate the general disposition of the seven pairs of thoracic limbs in relation to the body of the animal. Thus the generalised isopodan type of taxis, present, for example, in *Ligia* and in innumerable other Isopods, shows a perfectly regular and gradual change in the direction of the thoracic limbs from before backwards. The Glyptonoteinæ have a specialised type of limb-taxis, in which the first three pairs of thoracic limbs, mesially directed, are sharply separated from the last four pairs, which are laterally and posteriorly directed. In Harger's (1880) figures of *Chiridotea*, representing in each case a dorsal view, the three anterior limbs have been pulled into an unnatural position in order to represent in a single picture as much detail as possible; thereby the abrupt change in direction between the anterior and the posterior group of limbs has been obscured. The observations on the living *Chiridotea*, which establish the special service of its peculiar taxis in connection with tunnelling, warrant the conjecture that all the Glyptonoteinæ are tunnellers. Here we may note that *Mesidotea* is found on gravel, sand, or mud, *Macrochiridotea* apparently in similar territory, while the fossil *Proidotea* was obtained from a muddy or marly deposit. It is also of interest here to observe that the Ægidæ, which have a similar type of limb-taxis, though with a wholly different pleon, are also found on gravelly, sandy, or muddy ground.

The forepart of the body of *Chiridotea* is like a sharp shovel, and bears a certain resemblance to the shield of *Apus* or of *Limulus*, also to the

body of *Serolis*. This shovel shape, likewise characteristic of the extinct trilobites and of *Molaria*, is an adaptation to life on the surface of mud or of sand, whence, too, the frequent preservation of certain of these shovel forms as fossils. The conditions to which *Chiridotea* has to conform are, however, different from those of the aforesaid animals, for *Chiridotea* forcibly ploughs its way through a resistant mass of particles which are large and heavy in proportion to its size. For this reason its body does not exhibit the same degree of breadth combined with flattening, nor are its eyes mesially approximated and set upon the central eminence of the head. Its limbs, four of which are conspicuously stout and project far beyond the side of the body, do not in any way resemble the feeble appendages so characteristic of Arthropoda that skim over the surface of mud and lightly settle out of sight in this mobile medium. Whether *Glyptonotus* and *Mesidotea*, which are so obviously designed on the pattern of *Chiridotea*, are likewise accustomed to plough their way through heavy obstruction, *e.g.* gravel or anchor-ice,* is a question that can of course be finally solved only by observation on the living forms.†

Eyes and Chromatophore System.—*Glyptonotus* has one pair of eyes on the dorsal and another on the ventral aspect of the head, and examination of the spirit specimens indicated that the animal is capable of undergoing colour change by expansion or retraction of its chromatophores. Colour change in response to the mode of illumination of the animal has been recorded in Isopods only in cases where the eyes point ventrally as well as dorsally (*cf.* V. Bauer (1905), Tait (1910, 1911, 1925)). It was therefore of interest to find that *Chiridotea*, in which the eyes are directed only dorsally, undergoes no obvious colour change in response either to a dark or to a light background (the exposure was continued for days on end). At the same time it bears on various parts of its body both black and brown chromatophores, of which the former certainly vary in size from time to time, though under conditions that yet await determination (*cf.* Hogben (1924)).

The Sub-family Glyptonoteinæ.—Miers (1883) originally divided the family Idoteidæ into two sub-families, Idoteinæ and Glyptonoteinæ. Racovitza and Sevastos (1910), who are strong believers in parallel

* Dr H. T. Barnes informs me that this name is applied to a mushy, granular form of ice, like the *frazil* of Canadian rivers, which tends under special conditions to form at considerable depths on stones, seaweed, and other projecting objects.

† Frits Johansen has fully established that *Mesidotea entomon* is a sand-tunneller. His interesting field observations on *Mesidotea*, incorporated in Boone's (1920) report on the "Isopoda of the Canadian Arctic," became known to me only after the present communication had been forwarded for publication.

evolution or convergence, have sought to establish a new sub-family Mesidoteinæ for the reception of *Proidotea*, *Mesidotea*, and *Chiridotea*. In so far as the innovation is designed to separate the northern more sharply from the southern representatives of Miers' Glyptonoteinæ it may be justified, but on this count alone. From the systematic point of view their departure from convention has decided disadvantages, and for these reasons: (1) They have entirely failed to prove that the northern and the southern forms owe their present resemblance to convergence. (2) The association of structural features on which Miers relied in establishing his sub-family is highly distinctive and, moreover, unique among the Idoteidæ. (3) The differences between the northern and the southern Glyptonotids being trivial compared with those that separate *Glyptonoteinæ*, Miers, from *Idoteinæ*, Miers, it follows that elevation of the northern Glyptonotid group to a rank and title equivalent to that of Idoteinæ upsets all canons of classificatory proportion. Isolated action of this kind on the part of workers dealing with a limited group from a limited point of view does not contribute to a sound or balanced taxonomy.

Summary.

1. Following upon a previous study of spirit specimens of *Glyptonotus*, observations have been made on live examples of *Chiridotea cœca* and *C. tuftsii* with the object of elucidating points relating to the natural history and structural peculiarities of the Glyptonoteinæ.

2. Though wholly carnivorous, *Chiridotea* is not a predaceous animal. Subsisting on portions of animals, already dead, which it discovers by persevering search aided by sense of smell, it is a scavenger rather than a hunter of living prey.

3. The uncommon division of the thoracic limbs in *Chiridotea* is associated with an exceptional range of locomotor accomplishments. The animal not only walks and swims like other members of the Idoteidæ, but also tunnels its way for long distances under the surface of sand.

4. The three pairs of gnathopods subserve a number of functions. They are used in ordinary reptant progression. They are used to seize and hold on to food, but not to tear or rend it. Working in conjunction with the mandibles, they play an essential part in the process of manducation. They also come into action during sand-tunnelling.

5. On closer observation the characteristic type of limb-taxis of *Chiridotea* proves to be specially related to the tunnelling habit. During the process of tunnelling the mesially situated gnathopods and pleopods,

working together, deal with one body of sand, the laterally projecting peræopods with another.

6. Certain common features in the bodily conformation of *Serolis*, of *Apus*, of *Limulus*, and of Trilobites are interpreted as an adaptation, by convergence, to a habitat on the surface of mud.

7. Owing to the transparency of its body, the movements of the alimentary canal of *Chiridotea* can be observed during ingestion and the movements of the hepatic cæca during digestion of food.

8. The midgut exhibits, according to circumstances, two different types of peristaltic movement. At the very commencement of a meal, and also during long continued vain effort to masticate a tough morsel of food, a succession of forward-running waves of contraction is observed. When food begins to be swallowed these are replaced by backward-coursing waves of contraction.

9. There are two pairs of hepatic cæca. As the midgut fills the more mesial pair passes out of sight. The laterally situated cæca increase greatly in volume and exhibit a series of dilatations or pockets, which enter into vigorous and long-sustained rhythmic contraction.

10. The mesial split in the thoracic sternites is a device for allowing distension of the body after a meal.

11. Its eyes being wholly dorsal, *Chiridotea* shows no conspicuous colour change in response to its background. It has both brown and black chromatophores, the latter contractile.

12. A new point of specific difference between *C. cæca* and *C. tuftsii* is recorded.

13. The direction of rotation by which the uropods of Valvifera have assumed their present orientation is discussed anew, the conclusion again being that the anterior border was originally mesial.

14. Objections are raised against the elevation by Racovitza and Sevastos of the northern representatives of Miers' Glyptonoteinæ to independent sub-family rank.

I wish to record my indebtedness to the Biological Board of Canada for an opportunity to make these observations at St Andrews, N.B.; to Dr Huntsman, Director of the Atlantic Biological Station, and to his assistant, Dr Leim, for help and facilities courteously provided; also to my wife for very considerable assistance.

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(*Issued separately January* 28, 1927.)